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ABSTRACT

This paper reviews the literature on factors affecting students' performance in undergraduate statistics courses for the social sciences. Statistics anxiety and attitude have been linked to one's performance in statistics classes. Math factors, such as anxiety and attitude, may have an impact on performance in statistics classes, but the relationship is unclear. Computer experience reduces the anxiety and improves the attitudes of some students, but it is important that the experience be positive. The research on gender identity as a predictor of performance in statistics courses, is unclear, whereas gender differences in statistics achievement are tied to the outcome measures used (i.e. examination grades or course grades). Directions for future research, especially with regard to attitudes and gender identity, are discussed. (Contains 82 references.) (Author/SLD)

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# Factors Affecting Undergraduate Performance in Statistics:

# A Review of Literature

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**ABSTRACT**

This paper reviews the literature on factors affecting students' performance in undergraduate statistics courses for the social sciences. Statistics anxiety and attitude have been linked to one's performance in statistics classes. Math factors, such as anxiety and attitude, may have an impact on performance in statistics classes, but the relationship is unclear. Computer experience reduces the anxiety and improves the attitudes of some students, but it is important that the experiences be positive. The research on gender identity, as a predictor of performance in statistics courses, is unclear whereas gender differences in statistics achievement are tied to the outcome measure used (i.e., exam grades or course grades). Directions for future research are discussed.

# Factors Affecting Undergraduate Performance in Statistics: A Review of Literature

Most undergraduate social science programs require at least one semester of statistics for graduation. This course coupled with one or two semesters of college algebra is all the math many social science majors take in their undergraduate career. Since the social sciences are not heavily math oriented, when a student enrolls in introductory statistics it is usually with some apprehension. With so much fear of statistics it seems logical that the causes and correlates of statistics performance would be well documented and understood, but this is not the case.

Research into the causes and correlates of statistics performance is sparse. More research has been conducted to determine factors that influence student performance in math courses. Both statistical and mathematical research have been summarized in this literature review. Fifteen factors, potentially related to statistics performance, were discovered. These factors were combined into one of four categories for organizational purposes: statistics factors, technology factors, person factors, and math factors.

## Statistics Factors

The anecdotal evidence is overwhelming that students are scared of statistics (Bibby, 1986; Clegg, 1982). One's feelings and perceptions about statistics may influence what is learned in class. In fact, research has shown that anxiety can be detrimental to performance (Chapin, 1989; Kleijn, Van Der Ploeg, & Topman, 1994). Within the present context, statistics anxiety and statistics attitude could have a significant impact on one's performance within the statistics class.

### Statistics Anxiety

Statistics anxiety is a type of performance anxiety typified by worry, physiological arousal, and mental disorganization that arises in response to statistics as a subject area (Zeidner, 1992).

Although Birenbaum & Eyelath (1994) did not find a link between statistics anxiety and course performance, others found a negative relationship (Elmore, Lewis, & Bay, 1993; Lalonde & Gardner, 1993; Zeidner, 1992).

The discrepant results may be due to differences in the operational definition of statistics anxiety. Birenbaum & Eyelath (1994) used a single item to measure statistics anxiety; subjects were asked to rate their level of statistics anxiety using a Likert response, with (1) indicating no anxiety and (10) indicating very high anxiety. In contrast, Ziedner (1992) used the Statistics Anxiety Inventory (SAI), which is a 40 item inventory patterned after the condensed Mathematics Anxiety Rating Scale (MARS; Richardson & Woolfolk, 1980). Elmore, Lewis, and Bay (1993) used the Statistics Anxiety Rating Scale (STARS), which is a 51 item measure with six subscales (interpretation anxiety, test and class anxiety, computation self-concept, fear of asking for help, fear of statistics teacher). Finally, Lalonde & Gardner (1993) used five positively worded items to assess statistics anxiety, basing their measure on the French Use Anxiety measure (Gardner et al., 1979). Thus, it appears that statistics anxiety, when measured multidimensionally, is negatively related to statistics performance.

Statistics Attitude

The attitude one has about statistics can also influence performance. Statistics attitude, as defined by Wise (1985), consists of two facets. The first facet is attitude towards the course, and the second facet is attitude towards the usefulness of statistics in their field (Wise, 1985). Numerous scales have been developed to measure statistics attitude (Auzmendi, 1991; Lalonde & Gardner, 1993; Roberts and Bilderback, 1980; Wise, 1985). Auzmendi (1991) developed a multidimensional scale with five dimensions: enjoyment, anxiety, motivation, confidence, and usefulness. Lalonde and Gardner (1993) used a two part statistics attitude measure. The first part

used five positively worded and five negatively worded items to assess how important the subject thought statistics was to the field. The second part measured the subject's attitude toward learning statistics; this portion was based on Gardner et al. (1979) French use scale. Using these measures, statistics attitude has been found to be positively related with course grade (Lalonde & Gardner, 1993; Roberts & Bilderback, 1980; Roberts & Reese, 1987; Roberts & Saxe, 1982; Waters, Martelli, Zakrajsek, & Popovich, 1988; Wise, 1985). Ware and Chastain (1989), however, found that statistics attitude was unrelated to statistics performance when attitude was measured using a semantic differential scale (Osgood, Suci, & Tannenbaum, 1957). In summary, it appears that statistics anxiety can be detrimental to performance, whereas a positive attitude about statistics is associated with better performance in applied statistics classes.

**Technological Factors**

As is true with many areas of applied science, technological advances have changed the way statistics is taught. With the advent of statistical packages for the microcomputer, and the dramatic drop in calculator prices that occurred in the late 1970's, students may focus on the principles of statistics rather than the tedious, repetitive calculations. The use of technology, however, requires additional skills of the student and may impact student performance in the statistics courses.

This section reviews the literature regarding computer anxiety, computer attitude, and the role of calculators in course performance. Performance in statistics classes were typically not the focus of the research. Rather, most of the literature investigated the relationship between the use of computer technology and performance in math courses. But, the literature on computer use and math performance may provide some insight about performance in statistics courses.

Computer anxiety and computer attitudes are subcomponents of Jay's (1981) definition of computerphobia. First, computerphobia is a reluctance to talk or think about computers; second, it is a fear of, or anxiety toward, computers; and third, it is hostile thought about computers. For this review, computer anxiety is defined by the first two parts of computerphobia, and computer attitude is defined by the third part.

Computer Anxiety

Several measures have been used to assess computer anxiety. The Computer Attitude Scale (CAS; Loyd & Gressard, 1984) is one of the most frequently used measures of computer anxiety. The CAS consists of three subscales: anxiety, liking, and confidence. The most common finding was that computer anxiety decreased with increased computer experience (Dyck & Smither, 1994; Gressard & Loyd, 1984; Hunt & Bohlin, 1991; Koohang, 1986; Loyd & Gressard, 1984; Sigurdsson, 1991).

Computer anxiety has been found to be positively related to statistics anxiety (Sigurdsson, 1991) and statistical test anxiety (Benson & Bandalos, 1989), factors known to influence statistics performance. Statistical test anxiety is similar to general test anxiety, but focuses on one's feelings when taking a statistics test. The relationship between computer anxiety and statistics anxiety lends credence to the idea that computer technology may actually increase one's anxiety about taking an applied statistics course, despite the freedom it brings from performing tedious, repetitive calculations.

Just as computer anxiety has been found to relate to anxieties in other areas, it also has an impact on the expectations one has for the course. Computer anxious students expect to do worse and have more self-doubting, negative thoughts while working on a computer (Glass & Knight, 1988). This effect is hardly unique to computer anxiety. Sufferers of other types of anxiety also

have lowered expectations in their respective courses so these affective thoughts influence course performance whether the course is math, computer, or statistics related (Hyde, Fennema, Ryan, Frost, & Hopp, 1990; LeFerve, Kulak, & Heymans, 1992).

When other measures of computer anxiety are used, the results are similar to the CAS research. Computer anxiety, as defined by Raub (1981), was negatively correlated with computer experience and positively correlated with math anxiety (Morrow, Prell, & McElroy, 1986). Bellando and Winer (1985) also found computer anxiety to be positively related to math anxiety when they used Oetting's Computer Anxiety Scale (Oetting, 1983, cited in Bellando & Winer, 1985) and the Math Anxiety Rating Scale (Richardson & Suinn, 1972). Rosen, Sears, and Weil (1987), using the Computer Anxiety Rating Scale (CARS), found that computer anxiety was negatively correlated with computer attitudes, and alleviated by experience using a computer in a non-programming type setting.

In sum, computer anxiety is positively related to statistics anxiety, statistical test anxiety, math anxiety, and lowered expectations for the course. Computer anxiety may be alleviated with computer experience, especially if the experiences are positive. The thought of using computers to perform data analysis may actually worsen student fears about taking an applied statistics course. Instructors may need to be careful about the way computers are implemented in statistics courses, if they do not want to increase students' anxieties and worsen their attitudes. The increase in anxiety may indirectly hurt student performance in the course.

Computer Attitudes

Computer attitudes have been researched with various scales. The most popular was the Computer Attitude Scale (CAS) which has three subscales: anxiety, liking, and confidence (Loyd & Gressard, 1984). Other measures used to assess computer attitudes include the Computer

Attitude Scale (CATT; Dambrot, Watkins-Malek, Silling, Marshall, & Garver, 1985), the Attitudes Towards Computers Scale (ATCS; Rosen, Sears, & Weil, 1987), and the Computer Anxiety Rating Scale (CARS; Rosen, Sears, & Weil, 1987). The ATCS and the CARS were patterned after the Math Anxiety Rating Scale (Richardson & Suinn, 1972).

Many researchers have used the Computer Attitude Scale (CAS) to operationally define students' attitudes about computers. Using this definition, computer attitude was found to be positively related to statistics performance (Elmore, Lewis, & Bay, 1993) and statistics attitude, a factor that influences performance (Auzmendi, 1991). Computer attitudes were unrelated to statistics performance when using the ATCS to measure attitudes (Birenbaum & Eyelath, 1994).

Again using CAS's definition of computer attitudes, attitudes improved with additional computer experience (Hunt & Bohlin, 1991; Sigurdsson, 1991) and were positively correlated with attitudes about math (Payton & Loyd, 1984). Despite computer attitude's positive correlation with math attitudes, computer attitudes were unrelated to the grade one receives in math classes (Munger & Loyd, 1989). Dambrot et al. (1985) used the CATT to assess computer attitudes and found a negative relationship to math anxiety. Thus, the lack of relation between computer attitudes and math performance remains unclear.

The relationship between computer attitude and computer experience was further explored by Arthur and Olson (1991). They used path analysis to select between two theoretical explanations of the relationship between computer attitude and computer experience. Arthur and Olson's data indicated that negative attitudes were the result of negative computer experiences. As one's attitudes about computers increase, anxiety associated with computers is alleviated, as measured by the CARS and ACTS (Rosen, Sears, & Weil, 1987).

Not surprisingly, positive computer attitudes are associated with positive attitudes about statistics and success in statistics courses, just as computer anxiety is associated with increased statistical and statistical test anxiety. Positive computer attitudes were also associated with positive attitudes about math, but, unlike statistics, computer attitudes did not predict math performance. Finally, computer attitudes were negatively related to computer anxiety.

Calculators

Up to this point technology has been equated with computers. Computers are not the only technology used in statistics courses. Calculators free students from having to split attention between ancillary calculations and concentrating on learning the underlying concepts behind the calculations (Roberts & Glynn, 1979). The research on college students use of calculators indicate that calculators improved performance (Fabrey & Roberts, 1981; Kissler, Dreese, & Kissler, 1978; Munger & Loyd, 1989; Roberts & Glynn, 1979). Furthermore using a calculator reduces state anxiety levels (Fabrey & Roberts, 1981).

When the problem goes beyond simple computation and requires mathematical reasoning skills, however, calculators are of no value (Kissler, Dreese, & Kissler, 1978). Further, students using advanced calculators perform no better than students using a simple, four function calculator because the advanced calculators are used as simple ones, even after the students have been taught how to use the advanced functions (Roberts & Glynn, 1979). The research about calculator use in statistics courses indicates technology may overwhelm some students, even when those students have been given the proper training.

**Person Factors**

In addition to attitudes and anxieties related to statistics, technology, and math, one's personal history also influences performance in applied statistics courses. Prior research has

investigated the relationship of GPA, test anxiety, gender, gender identity, spatial ability, personality, and age to performance in statistics classes. Some of the more interesting and controversial factors surrounding statistics performance are person factors such as gender, gender identity, spatial ability, personality, and age. The literature on GPA and test anxiety are included as well.

GPA

College GPA is positively related to performance in statistics (Ware & Chastain, 1989) and other courses (Dambrot, et al., 1985). This is only to be expected as past academic success should be indicative of future success.

Test Anxiety

Test anxiety and statistical test anxiety are factors that would be expected to influence statistics performance. Test anxiety and statistical test anxiety are similar, but not identical constructs (Benson, 1989). Statistics test anxiety is similar to general test anxiety, but focuses on one's feelings when taking a statistics test. The sparse research on statistics test anxiety indicates a negative relationship to test and course performance (Bandalos, Yates, & Thorndike-Christ, 1995; Benson, 1989). Benson (1989) also found that females had higher levels of statistical, as well as general, test anxiety.

More is known about test anxiety, in general, than is known about statistics test anxiety. Social support networks can have a moderating effect on general test anxiety. Peers not in the class and family relationships can help reduce test anxiety, while peer support groups within the class do nothing to alleviate test anxiety (Orpen, 1996). When the effects of in class peers are investigated further, in class peers do help alleviate some anxiety in low test anxiety students. On the other hand, for high test anxiety students, in class peer relationships increase test anxiety

(Goldsmith & Albrecht, 1993). The reason for this is not clear, but one explanation is that by working with peers in the class the high test anxiety student realizes what areas they are not prepared for, and this heightens their anxiety level (Goldsmith & Allbrecht, 1993).

Time allotment is another factor that moderates the effects of test anxiety. Students with high test anxiety perform better without time constraints than they do in a timed condition, while low test anxiety students do equally well in either situation (Onwuegbuzie, 1994; 1995; Onwuegbuzie & Seaman, 1995). By giving high anxiety students enough time to complete the exam, the negative effects of worrying about time remaining are removed and a clearer picture of true knowledge is gained. More research is needed into which factors have mediating effects on statistical and general test anxiety. As the research has shown, moderating variables such as time and peer support, influence the anxiety one experiences when taking tests.

Gender

One area that has been heavily researched is gender. Overall, males and females do not differ in their statistics performance (Elmore & Vasu, 1980; Fenster, 1992; Harvey, Plake, & Wise, 1985; Mogull, 1989; Ware & Chastain, 1989; Woehlke & Leitner, 1980). Schram's (1996) meta-analysis of gender and it's role in statistics achievement indicates that females outperform males in statistics when the criterion is overall course peformance, but that males outperform females when the criterion is exam grades. In contrast, males and females are typically found to differ on math performance (e.g., Entwisle, Alexander, & Olson, 1994; Randhawa & Randhawa, 1993) and the problem solving techniques used for math (Ethington, 1992). Although Randhawa and Randhawa found gender differences in math achievement, they did not find gender differences on the statistics portion of the math achievement test. Thus, it seems that different abilities are needed for solving statistics and math problems. Gender does not seem to have as much impact on

statistics performance as it does on math performance. One confound to these conclusions, however, is that much of the math research has used high school age students or younger, whereas the statistics research used college students as subjects.

Spatial Ability

Tobias (1993) reports that males consistently outperform females on tests of spatial ability, but this has been challenged by others (Casey, Pezaris, & Nuttall, 1992; Van Blerkom, 1985).These researchers have found that other mitigating factors were responsible for the gender differences seen in spatial ability. Spatial ability has been positively associated with math performance (Casey, Pezaris, & Nuttall, 1992; Tobias, 1993; Van Blerkom, 1985) as well as statistics performance (Elmore & Vasu, 1980).

Azumendi (1991) did not find a link between spatial ability and statistics attitude or anxiety, though she did find it was predictive of one's confidence to work statistics problems at the end of the course, but not at the beginning. It seems that one's math skills provides a sense of security when faced with more challenging statistical concepts.

Gender Identity

Gender identity, rather than gender, may explain some of the differences in statistics performance. The research yields conflicting information on the role that gender identity plays in one's statistics performance. It seems largely tied to how gender identity is defined, i.e., which measure is used. Gender identity is measured in one of two ways. Tests such as the California Psychological Inventory and MMPI view masculinity and femininity as the endpoints of a spectrum and people lie along the continuum. The Bem Sex Role Inventory (BSRI), in contrast, views masculinity and femininity as separate continuums with each person having scores on both.

When gender identity was measured unidimensionally using the MMPI, Elmore and Vasu (1980) found masculinity to be positively correlated with statistics performance. They also found that females were higher than males on the M-F subscale. A multidimensional measure of gender identity has not been used to determine whether gender identity is related to statistics attitude, anxiety, or performance.

The remainder of the literature focused on gender identity issues associated with math performance. Lambert (1960) found that females majoring in math were more feminine as defined by the MMPI while Stamp (1979) found that females choosing to take math were more masculine on the CPI.

The multidimensional measure of gender identity, the BSRI, was used by several researchers to determine any impact that gender identity has on math performance. Blackman (1986) studied the BSRI responses of math oriented and nonmath oriented females. Gender identity was not found to be significantly related to math ability. Confounding this result is the fact that the nonmath oriented group was on average ten years older than the math oriented group. Plake, Kaplan, & Steinbrunn (1986) found highly masculine and highly feminine students did not differ in math achievement, but outperformed androgynous and undifferentiated students. Van Blerkom (1985), however, found that people high in femininity did not do as well in math and took fewer math courses.

Whether measured unidimensionally or multidimensionally, the relationship between gender identity and math performance is unclear. A meta-analysis focusing on gender identity might provide some insight into whether these findings are truly contradictory or whether gender identity plays only a small role in math performance. The relationship of gender identity to statistics performance, attitude, and anxieties has not been thoroughly researched. Just as gender

was less important for statistics than mathematics, gender identity may also be less important for statistics.

Age

Age has also been shown to be related to one's performance in statistics classes. Sagaria (1989) found that nontraditional students did one letter grade better than the traditional students in introductory statistics. The nontraditional students did better in spite of the fact that the traditional students received more in depth presentations and more application problems. By not keeping the teaching condition the same, however, one cannot be certain that the differences were due to age. In fact, age and math anxiety have been shown to be unrelated (Bitner, Austin, & Wadlington, 1992; Calvert, 1981). The conclusions drawn from Calvert (1981) may have been limited by range restriction for age; most of the students were between 18 and 21 years of age. Additional research in this area would be helpful. Another factor that has not been investigated, related to age, but not the same, is the length of time since the last math or statistics related course.

Personality

No literature was found that addressed personality and it's relationship to statistics. Some personality research has been conducted on math students, however, because of dwindling enrollments in math classes. In general, students choosing to take more advanced math courses have been found to be more stable and tough minded. When analyzed by gender, females were more adventerous, sociable, self-opinionated, and anxious than males (see Odom & Shaughnessy, 1989; Siegel & Shaughnessy, 1992; Stamp, 1979 for more details).

Personality research that focused on other math-related fields indicate that math teachers scored lower than engineers on creative and independence measures (Handley & Hickson, 1978).

Personality research that focused on less math-related fields indicated that research-oriented social workers scored higher on orderliness, endurance, and achievement measures while clinically-oriented social workers scored higher on affiliation and nurturance (Drisko, 1993).

Applied statistics classes, such as those within psychology, are mostly comprised of students with a clinically-oriented nature. In fact, undergraduate psychology majors view clinical work as the most attractive option within psychology (Quereshi, Brennan, Kuchan, & Sackett, 1974; Smith, 1982). To the extent that personality influences one's field of study, then, it would seem that students in applied statistics classes may face statistical, mathematical, and technological challenges that they are less prepared to meet than students who have chosen a math-related field of study. Morris, Kellaway, & Smith (1978) found that psychology students have higher math anxiety than math students, which lends support to the idea that students in applied statistics courses are generally out of their area of expertise. Personality research that explicitly investigates the role of personality and performance in applied statistics courses would be informative.

**Mathematical Factors**

Math Anxiety

Very little research has been conducted into the relationship between math anxiety and statistics performance. Birenbaum and Eyelath (1994) did not find a relationship between math anxiety and statistics performance, whereas Adams and Holcomb (1986) found a negative relationship. Gourgey (1984) found that math anxiety was strongly related to math avoidance. Math anxious students tended to abandon a problem when the solution was not immediately apparent or simply not attempt the problems. Further, students with higher math anxiety take fewer math courses (Brush, 1978; Calvert, 1981). Math efficiency, which consists of math

anxiety, math attitude, arithmetic and algebraic skills, statistics achievement, and state anxiety, can be described as using one's energy, time, and skills in an effective manner. As such, math efficiency is positively related to math performance (Adams & Holcomb, 1986).

Math Attitude

Math attitude's relationship to statistics performance is not clear. Three studies found no relationship between the two (Adams & Holcomb, 1986; Birenbaum & Eyelath, 1994; Elmore & Vasu, 1980), while one study found a positive relationship between math attitude and statistics performance (Feinberg & Halperin, 1978). It was stated in the Feinberg & Halperin (1978) study that the measure of math attitude specifically measured attitudes toward arithmetic. It could be that attitudes toward arithmetic are positively related to statistics performance while attitude toward math as a field are not.

In sum, then, math anxious students tend to avoid situations that require advanced math skills because they do not perform as well, whereas math efficient students perform better in math classes. Previous math achievement, whether measured by grades in prior courses or using a scale of math achievement, is correlated with statistics performance (Birenbaum & Eyelath, 1994; Harvey, Plake, & Wise 1985; Feinberg & Halperin, 1978). Thus, one would expect math anxious students to avoid statistics classes if possible. This avoidance might hurt their performance in statistics classes if they are inclined to abandon difficult problems.

**Directions for Future Research**

In the course of reviewing the literature surrounding statistics performance, many avenues for future research became apparent. Some factors were clearly related to statistics performance, while others were not so obvious, or conflicting results were discovered. Some factors have not

even been investigated with statistics performance. Lastly, the relationships between some of the factors need to be investigated as well.

Computer anxiety has been correlated with statistics anxiety, statistics attitude, and various math factors, but no research investigating its effects on statistics performance could be found.

The research on computer attitudes is conflicting. One study found a correlation between computer attitude and statistics performance (Elmore, Lewis, & Bay, 1993) while one did not (Birenbaum & Eyelath, 1994). These two studies used different scales to measure computer attitude. One area for future research is to conduct psychometric analyses of all the computer attitude scales to see if they are similar in the constructs they measure.

Initially, we were interested in personality differences that would influence statsitics performance. We could not find any research that addressed this issue.

Benson (1989) reported a .66 correlation between general and statistical test anxiety, indicating that general and statistical test anxiety are somewhat different measures. Research investigating differences between the two constructs may identify the unique role that statistical test anxiety has on performance in statistics courses.

All the research on gender identity centered on math course findings. It is not known how applicable math course findings are to statistics, investigation of gender identity on statistics anxiety, attitude, and performance is needed.

It is unclear whether a person's age impacts their performance in statistics classes. Even if age is a predictor, other factors such as time since last math course and number of prior math courses may better explain the impact on performance. Such research may be of prime importance as nontraditional students return to college.

References

Adams, N. A. & Holcomb, W. R. (1986). Analysis of the relationship between anxiety about mathematics and performance. Psychological Reports, 59, 943-948

Arthur, W. & Olson, E. (1991). Computer attitudes, computer experience, and their correlates: An investigation of path linkages. Teaching of Psychology, 18, 51-54.

Auzmendi, E. (1991). Factors related to attitudes toward statistics: A study with a Spanish sample. Paper presented at the Annual Meeting of the American Educational Research Association. (ERIC Document Reproduction Service No. 333 049)

Bandalos, D. L., Yates, K., & Thorndike-Christ, T. (1995). Effects of math self-concept, perceived self-efficacy, and attributions for failure and success on test anxiety. Journal of Educational Psychology, 87, 611-623.

Bellando, J., & Winer, J. L. (1985). Computer anxiety relationship to math anxiety and holland types. Paper Presented at the Annual Convention of the Southwestern Psychological Association (ERIC Document Reproduction Service No. 258 089)

Benson, J. (1989). Structural Components of statistical test anxiety in adults: An exploratory model. Journal of Experimental Education, 57, 247-261.

Benson, J. & Bandalos, D. (1989). Structural components of statistical test anxiety in adults: An exploratory model. In H. M. van der Ploeg, R. Schwarzer (Eds.), Advances in Test Anxiety Research (Vol. 6 pp. 137-150). Hillsdale NJ: Erlbaum.

Bibby, J. (1986). Notes towards a history of teaching statistics. Edinburgh: John Bibby.

Birenbaum, M. & Eyelath, S. (1994). Who is afraid of statistics? Correlates of statistics anxiety among students of educational sciences. Educational Research, 36, 93-98.

Bitner, E., Austin, S., & Wadlington, J. (1992). The treatment of math anxiety and negative math self-concept in college students. College Student Journal, 26, 61-65.

Blackman, S. (1986). The masculinity- femininity of women who study college mathematics. Sex Roles, 15, 33-41.

Brush, L. R. (1978). A validation study of the mathematics anxiety rating scale (MARS). Educational and Psychological Measurement, 38, 485-490.

Calvert, E. L. (1981). A study of the relationship between level of mathematics anxiety and sex, age, mathematical background, and previous success in mathematics. Graduate Seminar Paper, Western Illinois University (ERIC Document Reproduction Service No. 200 265)

Casey, M. B., Pezaris, E., & Nuttall, R., L. (1992). Spatial ability as a predictor of math achievement: The importance of sex and handedness patterns. Neuropsychologia, 30, 35-45.

Chapin, (1989). The relationship of trait anxiety and academic performance to achievement anxiety: Students at risk. Journal of College Student Development, 30, 229-236.

Clegg, F. (1982). Simple Statistics. Cambridge: Cambridge University Press.

Dambrot, F. H., Watkins-Malek, M. A., Silling, S. M., Marshall, R. S., & Garver, J. A. (1985). Correlates of sex differences in attitudes toward and involvement with computers. Journal of Vocational Behavior, 27, 71-86.

Drisko, J. W. (1993). Personality and gender differences: Comparing clinicians and researchers. Smith College Studies in Social Work, 63, 147-161.

Dyck, J., & Smither, J. A. (1994). Age differences in computer anxiety: The role of computer experience, gender and education. Journal of Educational Computing Research, 10, 239-248.

Elmore, P. B., Lewis, E. L., & Bay, M. L. G. (1993). Statistics achievement: A function of attitudes and related experiences. Paper Presented at the Annual Meeting of the American Educational Research Association (ERIC Document Reproduction Service No. 360 324)

Elmore, P. B. & Vasu, E. S. (1980). Relationship between selected variables and statistics achievement: Building a theoretical model. Journal of Educational Psychology, 72, 457-467.

Entwisle, D. R., Alexander, K. L., & Olson, L. S. (1994). The gender gap in math: Its possible origins in neighborhood effects. American Sociological Review, 59, 822-838.

Ethington, C. A. (1988). Differences among women intending to major in quantitative fields of study. Journal of Educational Research, 81, 354-359.

Fabrey, L. & Roberts, D. M. (1981). Effects of calculator usage and task difficulty on state anxiety in solving statistical problems. Paper Presented at the Annual Meeting of the American Educational Research Association (ERIC Document Reproduction Service No. 202 705)

Feinberg, L. B. & Halperin, S. (1978). Affective and cognitive correlates of course performance in introductory statistics. Journal of Experimental Education, 46, 11-18.

Fenster, M. J. (1992). A diagnostic model predicting statistics performance of students in an urban environment. College Student Journal, 26, 300-309.

Frank, G. (1984). The boulder model: History, rationale, and critique. Professional Psychology: Research and Practice, 15, 417-435.

Gardner, R. C., Clement, R., Smythe, P. C., & Smythe, C. L. (1979). Attitudes and motivation test battery- Revised manual (Research Bulletin #15). University of Western Ontario, London.

Glass, C. R. & Knight, L. A. (1988). Cognitive factors in computer anxiety. Cognitive Therapy and Research, 12, 351-366.

Goldsmith, D. & Albrecht, T. (1993). The impact of supportive communication networks on test anxiety and performance. Communication Education, 42, 142-158.

Gourgey, A. F. (1984). The relationship of misconceptions about math and mathematical self-concept to math anxiety and statistics performance. Paper Presented at the Annual Meeting of the American Educational Research Association (ERIC Document Reproduction Service No. 254 417)

Gressard, C. & Loyd, B. H. (1984). An investigation of the effects of math anxiety and sex on computer attitudes. Paper Presented at the Annual Meeting of the American Educational Research Association(ERIC Document Reproduction Service No. 246 880)

Griswold, P. A. (1985). Differences between education and business majors in their attitudes about computers. AEDS Journal, 18, 131-138.

Handley, H. M. & Hickson, J. F. (1978). Background and career orientations of women with mathematical aptitude. Journal of Vocational Behavior, 13, 255-262.

Harvey, A. L., Plake, B. S., & Wise, S. L. (1985). The validity of six beliefs about factors related to statistics achievement. Paper Presented at the Annual Meeting of the American Educational Reseach Association (ERIC Document Reproduction Service No. 262 965)

Hunt, N. P. & Bohlin, R. M. (1991). Entry attitudes of students toward using computers. Paper Presented at the Annual Meeting of the California Educational Research Association (ERIC Document Reproduction Service No. 345 706)

Hyde, J. S., Fennema, E., Ryan, M., Frost, L. A., & Hopp, C. (1990). Gender comparisons of mathematics attitudes and affect. Psychology of Women Quarterly, 14, 299-324.

Jay, T. B. (1981). Computerphobia: What to do about it. Educational Technology, 22(1), 47-48.

Kissler, G. D., Dreese, C. W., & Kissler, J. M. (1978). The effects of student calculator use upon measures of numerical aptitude and business statistics. (ERIC Document Reproduction Service No. 160 447)

Kleijn, W. C., Van Der Ploeg, H. M., & Topman, R. M. (1994). Cognition, study habits, test anxiety, and academic performance. Psychological Reports, 75, 1219-1226.

Koohang, A. A. (1986). Computerphobia: An empirical study. (ERIC Document Reproduction Service No. 306 948)

Lalonde, R. N. & Gardner, R. C. (1993). Statistics as a second language? A model for predicting performance in psychology students. Canadian Journal of Behavioral Science, 25, 108-125.

Lambert, P. (1960). Mathematical ability and masculinity. The Arithmetic Teacher, 7, 19-21.

LeFevre, J. A., Kulak, A. G., & Heymans, S. L. (1992). Factors influencing the selection of university majors varying in mathematical content. Canadian Journal of Behavioral Science, 24, 276-289.

Leong, F. T. L. & Zachar, P. (1991). Development and validation of the scientist-practioner inventory for psychology. Journal of Counseling Psychology, 38, 331-341.

Loyd, B. H. & Gressard, C. (1984). The effect of sex age and computer experience on computer attitudes. Paper Presented at the Annual Meeting of the Eastern Educational Research Association (ERIC Document Reproduction Service No. 246 878)

Mogull, R. G. (1989). Comparitive gender performance in business statistics. Educational Research Quarterly, 13, 2-10.

Morris, L. W., Kellaway, D. S., & Smith, D. H. (1978). Mathematics anxiety rating scale: Predicting anxiety experiences and academic performance in two groups of students. Journal of Educational Psychology, 70, 589-594.

Morrow, P. C., Prell, E. R., & McElroy, J. C. (1986). Attitudinal and behavioral correlates of computer anxiety. Psychological Reports, 59, 1199-1204.

Munger, G. F., & Loyd, B. H. (1989). Gender attitudes toward computers and calculators: Their relationship to math performance. Journal of Educational Computing Research, 5, 167-177.

Odom, J. & Shaughnessy, M. (1989). Personality and mathematical achievement. Psychological Reports, 65, 1195-1201.

Oetting, E. R. (1983). Manual for Oetting's computer anxiety scale. Ft. Collins, CO: Rocky Mountain Behavioral Science Institute, Inc.

Onwuegbuzie, A. J. (1995). Statistics test anxiety and female students. Psychology of Women Quarterly, 19, 413-418.

Onwuegbuzie, A. J. (1994). Examination-taking strategies used by college students in statistics courses. College Student Journal, 28, 163-174.

Onwuegbuzie, A. J. & Seaman, M. A. (1995). The effect of time constraints and statistics test anxiety on test performance in a statistics course. Journal of Experimental Education, 63, 115-124.

Orpen, C. (1996). The interactive effects of social support and test anxiety on student academic performance. Education, 42, 464-465.

Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1957). The Measurement of Meaning, Urbana, IL; University of Illinois Press.

Payton, J. & Loyd, B. H. (1984). Math attitudes and computer attitudes among college students. Paper Presented at the Annual Meeting of the Northeastern Educational Research Association (ERIC Document Reproduction Service No. 253 433)

Plake, B. S., Kaplan, B. J., & Steinbrunn, J. (1986). Sex role orientation, level of cognitive development and mathematics performance in late adolescence. Adolescence, 21, 607-613.

Quereshi, M. Y., Brennan, P. J., Kuchan, A. M., & Sackett, P. R. (1974). Some characteristics of undergraduate majors in psychology. The Journal of Experimental Education, 42, 65-70.

Randhawa, B. S. & Randhawa, J. S. (1993). Understanding sex differences in the components of mathematics achievement. Psychological Reports, 73, 435-444.

Raub, A. C. (1981). Correlates of computer anxiety in college students. Unpublished doctoral dissertation, University of Pennsylvania.

Richardson, F. C. & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. Journal of Counseling Psychology, 19, 551-554.

Richardson, F. C. & Woolfolk, R. L. (1980) Mathematics anxiety. In I. G. Sarason (Ed.), Test Anxiety: Theory, Research, and Applications. Hillsdale, NJ: Erlbaum. Pp 115-143.

Roberts, D. M. & Bilderback, E. W. (1980). Reliability and validity of a statistics attitude survey. Educational and Psychological Measurement, 40, 235-238.

Roberts, D. M., & Glynn, S. M. (1979). Teaching introductory statistics for psychology: Effects of calculators on performance and motivation. Perceptual and Motor Skills, 48, 563-569.

Roberts, D. M. & Reese, C. M. (1987). A comparison of two scales measuring attitudes toward statistics. Educational and Psychological Measurement, 47, 759-764.

Roberts, D. M. & Saxe, J. E. (1982). Validity of a statistics attitude survey: A follow up study. Educational and Psychological Measurement, 42, 907-912.

Rosen, L. D., Sears, D. C., & Weil, M. M. (1987). Computerphobia. Behavior Research Methods, Instruments, and Computers, 19, 167-179.

Sagaria, S. D. (1989). Teaching traditional and non-traditional age individuals: How should methods, expectations, and standards differ? Paper Presented at the Annual Meeting of the American Educatiional Research Association (ERIC Document Reproduction Service No. 308 363)

Schram, C. M. (1996). A meta-analysis of gender differences in applied statistics achievement. Journal of Educational and Behavioral Statistics, 21, 55-70.

Siegel, C. & Shaughnessy, M. F. (1992). Personality of college students in calculus courses. Psychological Reports, 71, 1309-1310.

Sigurdsson, J. F. (1991). Computer experience, attitudes toward computers and personality characteristics in psychology undergraduates. Personality and Individual Differences, 12, 617-624.

Smith, G. F. (1982). Introducing psychology majors to clinical bias through the adjective generation technique. Teaching of Psychology, 9, 238-239.

Stamp, P. (1979). Girls and mathematics: Parental variables. British Journal of Educational Psychology, 49, 39-50.

Tobias, S. (1993). Overcoming Math Anxiety-Revised and Expanded. New York, NY: W. W. Norton & Company.

Van Blerkom, M. L. (1985). Mathematical ability in college students: A causal analysis. Paper Presented at the Annual Convention of the American Psychological Association (ERIC Document Reproduction Service No. 268 473)

Ware, M. E. & Chastain, J. D. (1989). Person variables contributing to success in introductory statistics. Paper Presented at the Annual Meeting of the Southwestern Psychological Association (ERIC Document Reproduction Service No. 309 927)

Waters, L. K., Martelli, T. A., Zakrajsek, T., & Popovich, P. M. (1988). Attitudes toward statistics: An evaluation of multiple measures. Educational and Psychological Measurement, 48, 513-516.

Wise, S. L. (1985). The development and validation of a scale measuring attitudes toward statistics. Educational and Psychological Measurement, 45, 401-405.

Woehlke, P. L. & Leitner, D. W. (1980). Gender differences in performance on variables related to achievement in graduate-level educational statistics. Psychological Reports, 47, 1119-1125.

Zeidner, M. (1992). Statistics and mathematics anxiety in social science students: Some interesting parallels. British Journal of Educational Psychology, 61, 319-328.